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## (54) RESISTANCE BUTT-WELDING APPARATUS

(71) We, INSTITUT ELEKTROSVARKI IMENI E.O. PATONA AKADEMII NAUK UKRAINSKOI SSR, 69, ulitsa Gorkogo, Kiev, Union of Soviet Socialist Republics (U.S.S.R.) a state enterprise organised and existing under the laws of U.S.S.R., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to apparatus for the oil and gas industry, and more particularly, to apparatus for resistance butt-welding of casing pipes above a well head into a string and subsequent running thereof into the well.

There is known apparatus for resistance butt-welding of casing pipes above the well head into a string and subsequent running thereof into the well.

The principal component units of such apparatus are machines for resistance butt-welding of the casing pipes and a grip to deliver casing pipes into the welding machine and to run the welded casing string into the well, the grip being connected to a mechanism for vertical displacement thereof. However, the existing equipment does not allow full utilization of the advantages provided by the highly productive resistance butt-welding process. In this context, consideration should be given, first of all to the pipe grips, used on the drilling rigs, to deliver pipes to be welded into the welding machine and subsequently to lower down an extended casing string.

These grips are positioned outside the pipes being welded (or string). Therefore it is necessary to clear out the space in the joint zone for passing the grip together with the string until the top end of the string is positioned at the welding level. In other words, a necessity arises to move the welding machine away from the welding zone. Moving away and bringing in the welding machine reduce labour productivity in lowering down the casing string and also require additional bulky mechanisms for transferring the welding machine. The design of the apparatus as a whole is thus made substantially more complicated.

The existing apparatus for connecting casing pipes into a casing string employs two types of resistance butt-welding machines. The first type includes machines with side charging of casing pipes being welded. In these machines, clamping of the pipes is performed by means of two jaws, prism-like in shape, moving towards each other, and therefore from the engineering point of view it is impossible to distribute the clamping force uniformly over the perimeter of the pipe being clamped, which materially lowers the quality of centering and consequently the quality of welding. This is especially evident in welding low-rigidity pipes—e.g. thin-walled large diameter pipes. To allow for passing the grip positioned outside the pipe together with the casing string, the welding machines of this type have to be moved away from the welding zone by means of special mechanisms in the direction perpendicular to the well axis. This moving-away action cuts labour productivity.

Highest quality of welding is achieved by using welding machines of through-passing type. These machines include non-split housings embracing the pipes being welded, and casing pipe clamping mechanisms ensuring uniform distribution of the clamping force over the entire perimeter of the pipes being clamped. However, to clear out the space to pass the external grip together with the casing string being run down, these machines need to be installed on special-type telescopic hoists to displace the machine along the axis of the casing string. Additional mechanisms needed to move away and bring in the welding machine in this case also reduce labour

productivity.

In addition, by installing the welding machine on the telescopic hoist the level of welding occurs substantially above the drilling rig floor which is disadvantageous to the operator from the safety point of view.

The primary object of the invention is to provide apparatus for resistance butt-welding of casing pipes above a well head into a string and subsequent running thereof into the well, ensuring higher labour productivity as compared with known plant of this type.

Another object of the invention is to provide an apparatus for resistance butt-welding of casing pipes above the well head into a string and subsequent running thereof into the well, which does not require the use of additional devices or operations to bring in or move away the welding machine from the welding joint location.

One more object of the present invention is to provide apparatus which would minimize the amount of space occupied by equipment at the drilling rig.

Still another object of the invention is to provide apparatus which would improve safety in operation.

According to the present invention there is provided apparatus for resistance butt-welding of casing pipes above a well head into a casing string and subsequent running thereof into the well, comprising a resistance butt-welding machine having integral annular housings embracing the casing string and pipe being welded thereto and carrying mechanisms for clamping the ends of the casing string and of a pipe being welded thereto; a grip located coaxially with the annular housings of the welding machine, for gripping and delivering casing pipes into the welding machine and for running the welded casing string into the well; means connected to the grip for vertical displacement of the grip along the axis of the well; the grip having a maximum cross-sectional dimension not exceeding the outer diameter of the casing pipe so as to permit the welded casing string when supported by the grip to be lowered through the annular housings of the welding machine which is fixedly mounted above the well.

The design of the grip whose overall dimensions are not in excess of the outer diameter of a pipe being welded permits vertical displacement of the grip together with the string being lowered down with no need for additional operations for moving the welding machine relative to the welding zone. This in turn, allows for higher labour productivity and for the use of a stationary welding machine of the through-passing type yielding higher quality of welding as compared with other machines of similar type.

Further, the welding machine operating conditions and safety are improved.

Another feature of the present invention is that the pipe grip for delivering casing pipes incorporates a hollow rod connected to said means for vertical displacement, whose one end has a cylindrical surface, while the other end thereof has at least two wedge-like steps each in the form of a truncated pyramid with the longitudinal axis thereof coinciding with the longitudinal axis of the rod, and with the apex facing towards the rod end having the cylindrical surface, and wedge-like clamping jaws installed on each face of the pyramid for possible displacement along the face and such displacement ensuring radial displacement of the clamping jaws in the cross-sectional plane of the casing pipe until the clamping jaws rest against the inner surface of the clamping pipe.

Introduction of wedge-like steps opens the way to utilization of the wedge joint effect in clamping the pipe, that is to obtain a clamping force proportional to the weight of the pipe. The number of the wedge-like steps is selected with respect to the weight of the casing string being clamped with due consideration of the permissible stresses in the pipe walls at the place of their contact with the working surfaces of the clamping jaws. The hollow rod permits a rope to be placed inside thereof for an additional tool to be secured to its end, such as a weld flash remover.

The wedge-like jaws are adapted to be displaced along guides made on the faces of the pyramids of each step.

These guides ensure accurate orientation of the working surfaces of the clamping jaws in relation to the inner surface of the pipe being clamped, which improves clamping conditions and ensures constant contact between the jaws and the faces of pyramids.

The shape of the working surface of the clamping jaws should conform to the shape of the inner surface of the casing pipe and the working surface should have teeth directed perpendicular to the axis of the casing pipe.

Conformity of the working surface of the clamping jaws to the inner surface of the casing pipe assists in uniform distribution of the clamping force, while the teeth made on the working surface of the clamping jaws and directed perpendicular to the pipe axis increases the coefficient of friction with the contacting surfaces, and consequently increases also the clamping force.

It is preferable that if the jaws of each step, which are positioned in line with each other, should be rigidly connected by mechanisms for adjusting the distance between them, whereby compensation may be made for manufacturing errors in the clamping jaws and wedge-like steps of the rod.

The use of adjusting mechanisms between

the aligned jaws of each step contributes to uniform distribution of the clamping force between all jaws of all steps to obviate excessive stresses in the pipe being clamped.

It is most expedient to have the mechanism for adjusting the distance between the jaws in the form of two screws, with one of them of right-hand thread and connected to one of the clamping jaws, and with the other of left-hand thread and connected to the opposite jaw, the screws being interconnected by a nut with corresponding threads.

This design of the mechanism gives ready and reliable adjustment of the distance between the jaws, while being simple to manufacture.

It is most favourable to provide the cylindrical end of the rod with a sleeve capable of axial displacement thereof and connected to each clamping jaw of the upper step by means of a two-link mechanism.

The two-link mechanism connecting each upper jaw to the sleeve permits the jaws to move radially relative to the sleeve. At the same time the jaws together with the sleeve are can jointly move displacement along the axis of the rod which is necessary when clamping or releasing a pipe.

Another feature of the invention is that the outer surface of the sleeve is threaded and this thread carries a spacer nut with a part spherical surface.

In accordance with another feature of the apparatus each clamping jaw of the upper step mounts a pivoted spring-loaded lever for preliminary clamping of the casing pipe, having on the end thereof opposite to the pivoted joint a part spherical ribbed surface facing the inner surface of the casing pipe and a wedge-like surface cooperating with the part spherical surface of the spacer nut.

The spring-loaded lever and the spacer nut permit preliminary clamping of the pipe and only after this action the main clamping operation can be effected.

The present embodiment gives way to other design varieties of the apparatus which may be so constructed that each face of at least one wedge-like step of the rod carries a spring-loaded pin-type detent cooperating with a seat made in the corresponding clamping jaw in its extreme upper position.

The spring-loaded detent is capable of locking the clamping jaws in the extreme upper position, which in turn, defines a clearance between the working surfaces of the clamping jaws and the inner surface of the pipe to enable the internal grip to be introduced into or extracted from the pipe.

Other objects and advantages will become more fully apparent from a detailed description of its actual embodiment with reference to the accompanying drawings, in which:

Fig. 1 is a schematic general view of the apparatus for resistance butt-welding of casing pipes above the well head into a string and subsequent running it into the well, according to the invention;

Fig. 2 is a section taken along the line II-II of Fig. 1;

Fig. 3 is a section taken along the line III-III of Fig. 2;

Fig. 4 is a section taken along line IV-IV of Fig. 1;

Fig. 5 is a section taken along line V-V of Fig. 4;

Fig. 6 is a section taken along line VI-VI of Fig. 4;

Fig. 7 is a section taken along line VII-VII of Fig. 4;

Fig. 8 is a section taken along line VIII-VIII of Fig. 4.

The apparatus for resistance butt-welding of casing pipes above a well head into a casing and subsequent running thereof into the well comprises a welding machine 1 (Fig. 1) of the through-passing type and a grip 2 mounted in coaxial relationship with the welding machine 1 to deliver casing pipes 3 into the welding machine 1 and subsequently to run a welded casing string 4 into the well and connected to a mechanism 5 for its vertical displacement along the axis of the well. The welding machine 1 is stationary and is installed above the well on a rotary table 6 of a drilling rig 7. The mechanism 5 for vertical displacement of the grip 2 takes the form of a tackle system incorporated in the drilling rig 7.

The welding machine 1 (Fig. 2 and Fig. 3) incorporates lower and upper integral annular housings 8 and 9 embracing the casing string 4.

In the following description the housing 8 will be referred to as "lower" because it faces the well, and the housing 9—"upper".

Installed inside each housing 8 and 9 with possible turning about the longitudinal axis of the machine 1 is a holder 10.

On each housing 8, 9 of the welding machine 1 there are two pivotally installed cylinders 11. Cylinders 11 belonging to the lower housing 8 serve to clamp the casing string, while cylinders 11 belonging to the upper housing 9 serve for clamping the casing pipe in extending the welded casing string.

Rods 12 of cylinders 11 are connected by means of pivots 13 to corresponding holders 10.

Each housing 8, 9 incorporates radially movable clamping and current-feeding shoes 14 having wedge-like surfaces 15 and surfaces 16. For each of the clamping shoes 14, there are installed in each housing on axles 17 double-arm levers 18 having abutment members arm contacting the surfaces 16 of the shoes 14. Each holder 10 carries abutment members 19 fixed therein and each contacting the corresponding wedge-like surface 15 of the shoes 14 and serving to bring

the shoes 14 together towards the centre of the machine and clamping the pipe.

To move the shoes 14 away from the centre of the machine, shoulders 20 are provided on the holders for cooperating with the other arms of levers 18.

Secured to the upper housing 9 are cylinders 21 adapted to move the casing string 4 and the pipe 3 towards each other during of welding. Rods 22 of cylinders 21 are rigidly connected to the lower housing 8. Installed on rods 22 are clamping plates 23. Positioned between the clamping plate 23 and the lower housing 8 in coaxial relationship with the welding machine 1 is a circular welding transformer 24 connected through busbars 25 with clamping and current-feeding shoes 14. The lower housing 8 of the machine is fixed on the rotary table 6.

The grip 2 illustrated in Fig. 4, to deliver casing pipes into the welding machine and subsequently to lower down the welded casing string, comprises two ports which are in coaxial relationship with possible relative displacement. One of these ports comprises a hollow rod 26 (Fig. 5) whose one end has a cylindrical surface 27 (Fig. 4), while the other end includes two wedge-like steps 28.

The exact number of wedge-like steps 28 is determined by the design requirements depending on the weight of the casing string, casing pipe wall thickness and material, i.e. on the mechanical and geometric characteristics of the casing string. Each step 28 takes the form of a truncated pyramid with a longitudinal axis coinciding with the longitudinal axis of the rod 26, and with the apex facing towards the cylindrical end of the rod 26 which by means of an adapter element 29 is connected to the mechanism 5 for vertical displacement. The other part comprises wedge-like clamping jaws 30 (Fig. 5) installed on each face of the pyramid of each step 28 for possible displacement therealong to ensure radial displacement of the jaw in the cross-sectional plane of the casing pipe 3 until clamping jaws 30 come into contact with the inner surface of the casing pipe 3.

The cross-section of the wedge-like clamping jaws 30 matches the inner surface of the casing pipe 3 and the jaws 30 are provided with teeth 31 (Fig. 4) directed perpendicular to the longitudinal axis of the casing pipe 3. The teeth 31 increase the frictional force between the working surface of the jaws 30 and the pipe 3 when the latter is being clamped. The faces of the pyramids of the wedge-like steps 28 have guides 32 (Fig. 6) formed thereon which ensure proper orientation of the jaws 30 relative to the inner surface of the casing pipe 3. The wedge-like clamping jaws 30 of each step, positioned in line with to each other, are rigidly interconnected by mechanisms for adjusting the distance between them. These adjusting mechanisms serve to eliminate the effects of manufacturing errors of the clamping jaws 30 and the wedge-like steps of rod 26, which ultimately helps achieve uniform distribution of the clamping force among all jaws 30 and reduces the maximum stresses occurring in the pipe 3 or casing string 4. The mechanism for adjusting the distance between jaws 30 is made in the form of two screws 33 (Fig. 4) and 34 (Fig. 5) the screw 33 being of right-hand thread and connected to one of the clamping jaws 30, while the other screw 34 is of left-hand thread and connected to the opposite jaw 30; with this arrangement, screw 33 and 34 are interconnected by a nut 35 threaded in compliance with the screws. The cylindrical surface 27 of the hollow rod 26 is provided with a sleeve 36 (Fig. 7) connected to each clamping jaw 30 of the upper step next to the cylindrical end of the rod) by means of a two-link mechanism 37 enabling the clamping jaws 30 to displace relative to the axis of the rod 26 and, also, to move longitudinally relative to the axis of the rod 26 together with the sleeve 36.

The outer surface of the sleeve 36 is threaded to mount thereon a spacer nut 38 (Fig. 4) having at one point an outer part-spherical surface 39. Each clamping jaw 30 of the upper step 28 mounts by means of a pivot 40 (Fig. 8) a spring-loaded lever 41 having on its end opposite to the pivot 40 a part-spherical ribbed surface 42 (Fig. 4) facing the inner surface of the casing pipe 4, and a wedge-like surface 43 facing the spherical surface 39 of the nut 38 and cooperating with the latter for preliminary clamping of the pipe. A spring 44 (Fig. 8) of the lever 41 tends to urge the part spherical ribbed surface of the lever 41 away from the inner wall of the pipe, thus disconnecting the part spherical ribbed surface 42 from the inner surface of the pipe when it is desired to remove the grip out of the pipe.

Mounted in each face of one of the wedge-like steps 28 of the rod 26 is a spring-loaded pin-type detent 45 (Fig. 4) provided with a spring 46 and co-operating with a seat 47 made in the corresponding clamping jaw 30 in its extreme upper position to enable the grip to be inserted in or removed from the pipe.

The number of pin-type detents or steps provided with them is determined in accordance with the design depending principally on the weight and size of the movable components of the grip.

Thus, the apparatus made in accordance with the present invention, is provided with a grip whose maximum overall cross-sectional dimensions do not exceed the outer diameter d (Fig. 1) of the casing pipe 3 to permit its accomodation inside the casing pipe 3, and this in turn, makes it possible to install on the drilling rig a welding

machine of the through-passing type, thus improving the quality of welding.

The apparatus operates as follows.

The casing string 4 welded up to a certain length is run into the well and clamped in the rotary table 6 of the drilling rig 7. At this time, the upper end of the casing string is located at the welding level. The grip 2 is then prepared for introduction into one of the casing pipes 3 to be welded to the casing string 4 which are positioned on the drilling rig 7 in a vertical or inclined stack. For this purpose, the spacer nut 38 is turned to let springs 44 move levers 41 through a maximum value towards the longitudinal axis of the grip. Then, the wedge-like clamping jaws 30 are displaced along guides 32 of wedge-like steps 28 to the extreme upper position until springs 46 push the pin-type detents 45 into the seats 47. The Jaws 30, while being displaced along the guides of the wedge-like steps 28, approach the longitudinal axis of the grip 2 to establish a required clearance between the teeth 31 of its working surfaces and the inner surface of the casing pipe. During their displacement, the jaws 30 acting through the two-link mechanisms 37 force the sleeve 36 to move to the upper position. The mechanism 5 for vertical displacement is now applied to introduce the grip 2 into a next casing pipe 3 and the grip is fixed inside the pipe. To this end, the nut 39 is turned to act with its part spherical surface 39 on the wedge-like surfaces 43 of the levers 41. This makes the levers 41 turn round the pivots 40 which by depressing the springs 44 press with their part spherical ribbed surfaces 42 against the inner surface of the pipe 3 with a force proportional to the force applied to the nut 38. Then, through the mechanism 5, action is imposed via the adapter element 29 on the rod 26 to raise the latter. Under the weight of the pipe 3 transmitted to the grips 2 through levers 41 pressed against the pipe, the springs 46 are compressed, the detents 45 come out of their seats 47 and relative displacement takes place between the rod 26 and wedge-like clamping jaws 30 until the latter are pressed against the inner surface of the pipe 3. When this occurs, the two-link mechanisms 37 do not obstruct radial displacement of the jaws 30 relative to the longitudinal axis of the grip 2. Turning of the lever 41 through a small angle around the pivot 40 due to the displacement of the jaws 30 practically causes no reduction in the force of preliminary fixing (preliminary clamping) of the grip 2 inside the pipe because the working surface 42 of the lever 41 is part spherical in shape. After resting the jaws 30 against the inner surface of the pipe 3 and lifting the latter by the mechanism 5, the grip is loaded by the entire weight of the pipe; and the full force of clamping the pipe is proportional to its weight and depends on the coefficient of friction between the jaws 30 and the inner surface of the pipe and also on the angling of the wedge-like steps and the internal frictional forces.

The casing pipe 3 clamped by the grip 2 is inserted inside the upper housing 9 of the welding machine 1 until the lower end of the pipe is in line with the welding level. The casing pipe 3 and the casing string are clamped in the welding machine. This is done by admitting oil into spaces "A" (Fig. 3) of the cylinders 11 of the lower housing 8 and the upper housing 9. The Rods 12 of the cylinders 11 force their action through the pivots 13 on the holders 10 to turn the latter clockwise.

Abutment members 19 act on the wedge-like surfaces 15 of the clamping and current-feeding shoes 14 to displace the latter radially towards the central axis of the machine until they come into contact respectively with the outer surfaces of the casing pipe and the casing string. The welding transformer 24 is switched on and the welding process is carried out by bringing the housing 9 together with the casing pipe 3 clamped therein towards the casing 8 together with the casing string 4 clamped therein, by delivering oil to space "B" (Fig. 2) of cylinders 21. The housing 9 is displaced along the rods 22. On completion of the welding process, the casing pipe and the casing string welded together are released. This is obtained by supplying oil to space "C" (Fig. 3) of cylinders 11 of housings 8 and 9. The Rods 12 via pivots 13 turn the holders 10 counter-clockwise. The Holders 10 through their shoulders 20 act on the arms of double-arm levers 18 which when turning around axles 17 act with their other arms on the surfaces 16 of the shoes 14 to force the latter away from the central axis of the machine. Then, oil is admitted to space "D" (Fig. 2) of cylinders 21 to part housing 8 and 9, that is to return the welding machine to the initial position ready for the next welding operation. The casing string again elongated after welding another casing pipe is freed from clamping in the rotary table 6, and this loads the grip 2 with the full weight of the casing string. Using the mechanism 5 the string is run into the well until the upper end thereof is in line with the welding level; afterwards the casing string is again clamped in the rotary table 6.

With the help of the mechanism 5 the rod 26 is lowered down until the detents 45 enter the seats 47 due to the action of the springs 46. At this time all the remaining components are in the vertically fixed position relative to the pipe at the expense of the force of clamping the surfaces 42 of

the levers 41 against the inner walls of the pipe. When the rod 26 is moved down, the jaws 30 are displaced radially to establish a clearance between their working surfaces and the inner walls of the pipe. Then by turning the spacer nut 38 of the grip 2 the levers 41 are released from contact by their surfaces 42 with the inner walls of the pipe, whereupon the grip 2 is pulled out of the casing string by means of the mechanism 5. A new casing pipe is clamped, then brought into the welding machine and the procedure is repeated.

Discrepancies which may occur in the manufacture of the wedge-like steps 28 and the wedge-like clamping jaws 30, affecting the uniform contact of the latter on the inner walls of the pipe are eliminated by turning the nuts 35 in the appropriate direction. This is because the nuts 35 co-operating with the screws 33 and 34 force the aligned jaws 30 apart or bring them together.

WHAT WE CLAIM IS:—

1. Apparatus for resistance butt-welding of casing pipes above a well head into a casing string and subsequent running thereof into the well, comprising a resistance butt welding machine having integral annular housings embracing the casing string and pipe being welded thereto and carrying mechanisms for clamping the ends of the casing string and of a pipe being welded thereto; a grip located coaxially with the annular housings of the welding machine, for gripping and delivering casing pipes into the welding machine and for running the welded casing string into the well, means connected to the grip for vertical displacement of the grip along the axis of the well; the grip having a maximum cross-sectional dimension not exceeding the outer diameter of the casing pipe so as to permit the welded casing string when supported by the grip to be lowered through the annular housings of the welding machine which is fixedly mounted above the well.

2. Apparatus according to Claim 1, wherein the grip for delivering casing pipes incorporates a hollow rod connected to said means for vertical displacement whose one end has a cylindrical surface, while the other end thereof has at least two wedge-like steps each in the form of a truncated pyramid with the longitudinal axis thereof coinciding with the longitudinal axis of the rod, and with the apex facing towards the rod end having the cylindrical surface, and wedge-like clamping jaws installed on each face of the pyramid for possible displacement along the face such displacement ensuring radial displacement of the clamping jaws in the cross-sectional plane of the casing pipe until the clamping jaws rest against the inner surface of the clamping pipe.

3. Apparatus according to Claim 2, wherein the wedge-like clamping jaws are displaced along guides formed on the faces of each pyramid form wedge-like step.

4. Apparatus according to Claim 3, wherein the working surface of the clamping jaws conforms to the inner surface of the casing pipe and is provided with teeth directed perpendicular to the axis of the casing pipe.

5. Apparatus according to Claim 4, wherein those clamping jaws of the steps, which are located in line with to each other, are rigidly connected by mechanisms for adjusting the distance between them whereby compensation may be made for manufacturing errors of the clamping jaws and the wedge-like steps of the rod.

6. Apparatus according to Claim 5, wherein the mechanism for adjusting the distance between the jaws takes the form of two screws one of them being of right-hand thread and connected to one of the clamping jaws, while the other screw is of left-hand thread and connected to the opposite jaw; the screws being interconnected by a nut threaded in accordance with the screws.

7. Apparatus according to Claim 2, wherein the end of the rod having the cylindrical surface carries an axially displaceable sleeve connected to each clamping jaw of the upper step by means of a two-link mechanism.

8. Apparatus according to Claim 7, wherein the outer surface of the sleeve is threaded to mount a spacer nut having a part spherical surface.

9. Apparatus according to Claim 7, wherein each clamping jaw of the upper step pivotally supports a lever with a spring for preliminary clamping of the casing pipe, such lever having on the end thereof opposite to the pivotal mounting point joint, a part spherical ribbed surface facing the inner surface of the casing pipe, and a wedge-form surface adapted to cooperate with the part spherical surface of the spacer nut.

10. Apparatus according to Claim 2, wherein each face of at least one of the wedge-like steps of the rod mounts a spring loaded pin-type detent adapted to cooperate

with a seat in the corresponding clamping jaw when the jaw is located in the extreme upper position.

11. Apparatus for resistance butt welding of casing pipes above a well head into a casing string and subsequent running thereof into the well substantially as hereinabove described with reference to the accompanying drawings.

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**Sheet 1**

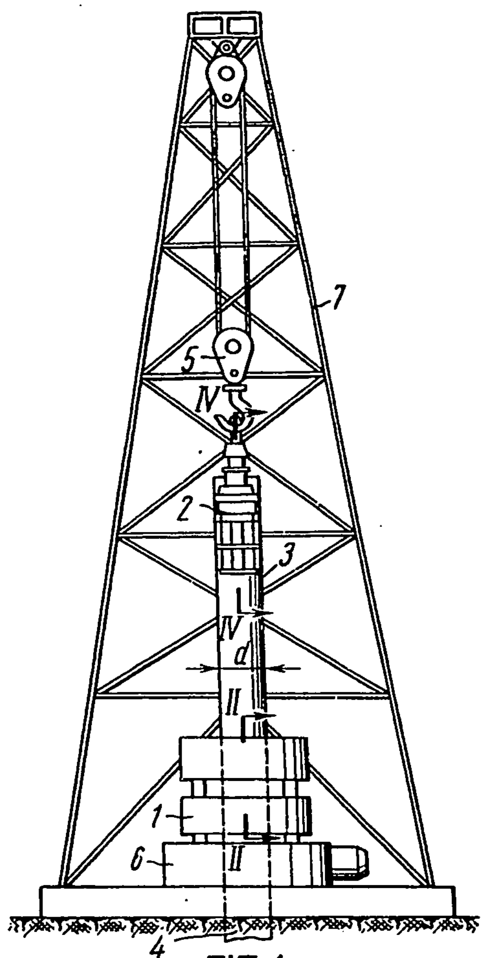


FIG.1

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Sheet 2

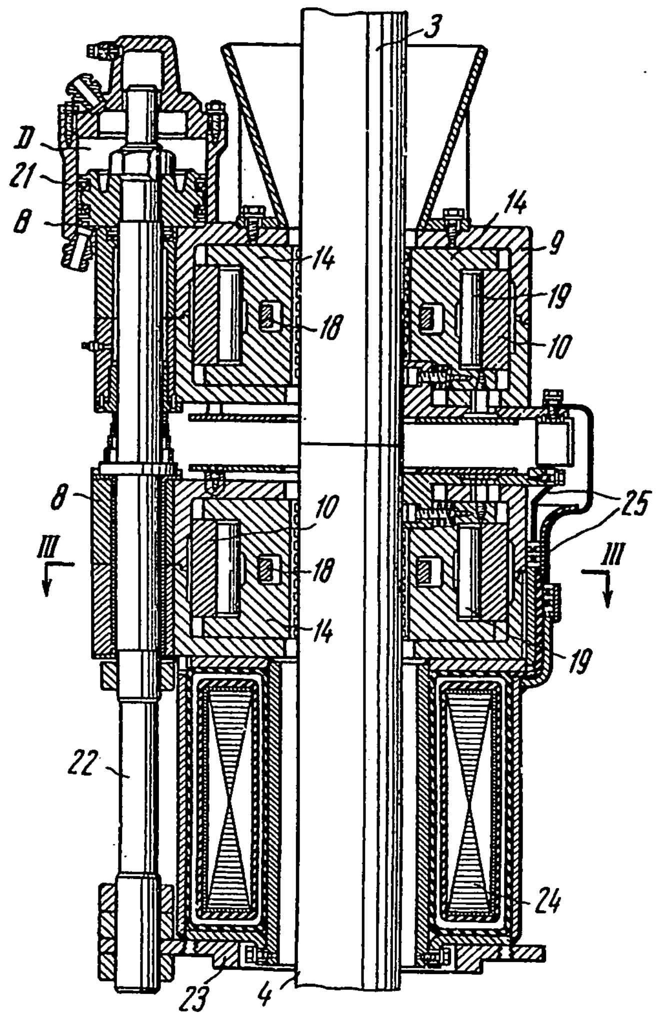


FIG. 2

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**Sheet 3**

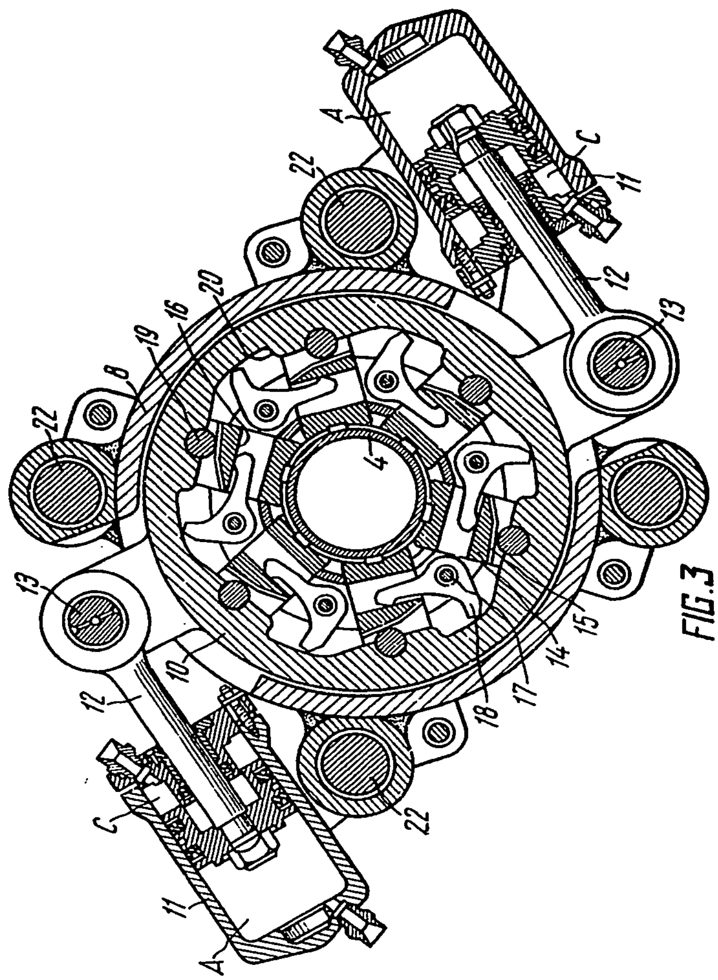


FIG.3

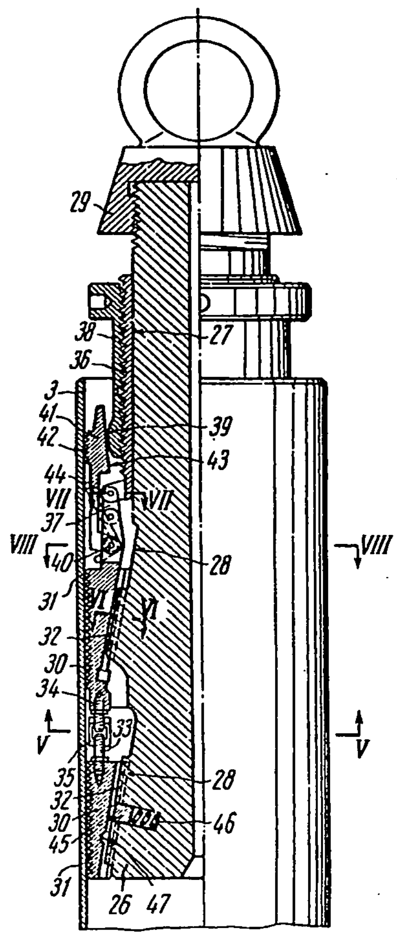
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FIG. 4

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 5

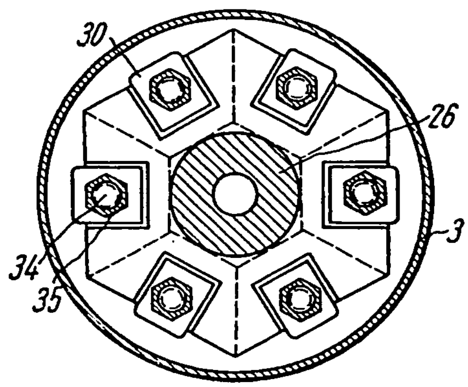


FIG.5

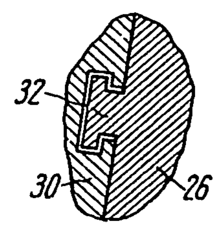


FIG.6

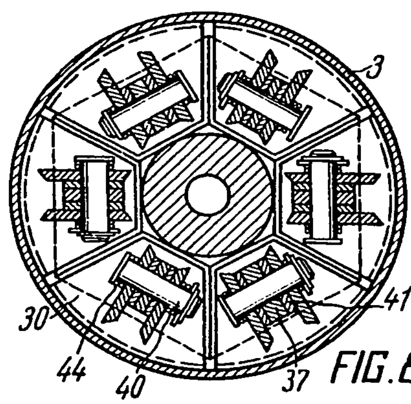


FIG.8

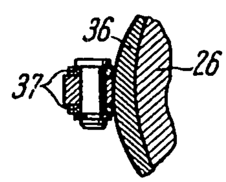


FIG. 7